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INDUSTRIAL WASTE SURVEY REPORT.  
FORD MOTOR COMPANY BY-PRODUCT COKE  
PLANT, DEARBORN, MICHIGAN, OCTOBER 23  
TO NOVEMBER 3, 1949

Charles E. Sponagle

Environmental Health Center  
Cincinnati, Ohio

3 November 1949

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**Studies on the Wastes of a By-Product Coke Plant**

**By**  
**Charles E. Sponagle**  
**Assistant Sanitary Engineer**

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### ABSTRACT

A survey of process wastes resulting from operation of the Ford Motor Company Coke Plant at Dearborn, Michigan, was undertaken by the Environmental Health Center, Public Health Service, with the cooperation of the Ford Motor Company. The survey covered the period from October 23 through November 3, 1949 and was carried out for the purpose of collecting detailed information regarding the wastes produced by this plant.

Coal was carbonized in coke ovens for production of blast furnace and foundry coke. Coking conditions during this survey were abnormal in that coking temperatures for production of blast furnace coke were from 350-400° F. lower than normal, while coking time had been doubled. This was necessitated by a coal shortage due to a strike in the coal fields.

Gas and liquor evolved in the process are treated for recovery of by-products, which include ammonium sulfate, naphthalene, tar and light oils. Following by-product recovery, coke-oven gas is stored and used for various purposes in the plant.

Principal process wastes are from the ammonia stills and final coolers. There is some liquid discharge from the decanters in the light oil plant, but only a very small volume comes from these units.

Unit values of major constituents of wastes were found to be: Phenol, 0.30 lb./ton coal carbonized; ammonia 0.44 lb./ton coal carbonized; cyanide 0.55 lb./ton coal carbonized; 5-day B.O.D. 9.1 lb./ton coal carbonized.

The waste flow per ton of coal carbonized was 2420 gal. from the final coolers, and 31.8 gal. from the ammonia still. The amount of coal carbonized varied from 2130 to 2309 tons per day, and averaged 2233 tons per day.

Results obtained from this survey are compared with those of a previous survey undertaken in 1947, when plant operation was normal. The 1947 survey disclosed unit waste discharge to be: Phenol, 0.14 lb./ton coal carbonized; ammonia, 1.2 lb./ton coal carbonized; cyanide, 0.76 lb./ton coal carbonized; 5-day B.O.D., 6.1 lb./ton coal carbonized.

Waste disposal is by dilution in the Rouge River through the tailrace outlet.

## General Information

### 1. Organization of Survey

Representatives of Ford Motor Company, Michigan Water Resources Commission, Michigan State Department of Health, and Public Health Service met on October 5, 1949 for a conference at the Rouge Plant Offices of the Ford Motor Company. The object of the conference was to discuss and outline proposed studies of wastes produced in operation of the by-product coke plant.

This survey resulted from that conference, and was a cooperative study undertaken by the Ford Motor Company and the Public Health Service.

### 2. Purpose of Survey

This survey was conducted to obtain detailed information regarding principal process wastes resulting from the operation of the Ford Motor Company by-product coke plant at Dearborn, Michigan.

### 3. Dates of Survey

The survey covered the period from 8 A.M. Sunday, October 23, 1949 to 8 A.M. Friday, November 3, 1949.

### 4. Plant Operations during Survey

Operations were constant, 24 hours per day (3 shifts, 8:00 A.M., 4:00 P.M., 12 Midnight) seven days per week.

183 coking ovens, arranged in three blocks of 61 each, were operated.

Coke output had been reduced to 50 percent of normal due to labor conditions in the coal industry.

### 5. Location of Plant

The Ford Motor Company Rouge Plant is located within an area bounded roughly by Schaeffer Road, Michigan Avenue, Miller Road, and the Rouge River, in Dearborn, Michigan.

### 6. Employees

Under normal conditions there are 575 employees in the coke plant.

During the survey, this force had been reduced to 464.

#### 7. Raw Materials

The average daily consumption of raw materials at the coke plant, for both normal and survey conditions, is as follows:

|                                         | <u>Normal</u> (1944-48) | <u>Survey</u> |
|-----------------------------------------|-------------------------|---------------|
| Coal                                    | 4300 tons               | 2240 tons     |
| Lime                                    | 2 tons                  | - -           |
| H <sub>2</sub> SO <sub>4</sub> (60° Be) | 39 tons                 | 21 tons       |

#### 8. Production

Average daily production of coke and by-products, for both normal and survey conditions, is as follows:

|                                 | <u>Normal</u> (1944-48) | <u>Survey</u>     |
|---------------------------------|-------------------------|-------------------|
| Coke                            | 3230 tons               | 1680 tons         |
| NH <sub>2</sub> SO <sub>4</sub> | 39 tons                 | 22 tons           |
| Gas                             | 44 million cu.ft.       | 23 million cu.ft. |
| Tar                             | 30,800 gal.             | 17,500 gal.       |
| Light Oil                       | 11,290 gal.             | 4,940 gal.        |

#### 9. Water Supply

Detroit River water is used for industrial purposes. A screen-house, containing ten 1/4" screens and wells arranged in parallel, is located on the old Zug Island Channel of the Rouge River. The water flows by gravity through two miles of 15-1/2 foot diameter tunnel to a pumping station located on the Rouge Plant property. This intake supplies industrial water for the entire Rouge Plant. Total consumption varies from 350 to 600 million gallons per day, depending upon the season of the year. Of this quantity 15 million gallons per day are used in the By-product Coke Plant under normal operating

conditions. During the survey period this had been reduced to 11 million gallons per day because of the decreased output.

Detroit City water is used for drinking and for the wash rooms. No estimate was obtained as to consumption from this source.

10. Sewers

All process wastes from the By-product Coke Plant are discharged into the tailrace outlet which empties directly into the Rouge River between Fort Street and Dix Avenue. This outlet collects wastes from the south-east area of the Ford Motor Company Rouge Plant. Other wastes entering the sewer are from the Power House, Foundry, Blast Furnaces, Locomotive Repair Shop, and the Maintenance Shops. The outlet is 12 feet in diameter.

11. Sanitary Sewage

All sanitary wastes discharge to the Dearborn municipal sewers.

### DISCUSSION OF PROCESS

The process consists of carbonizing suitable mixtures of pulverized coal under carefully controlled conditions to produce coke for use in the foundry and blast furnaces and also to produce fuel gas for various plant heating operations. Tar, ammonia, naphthalene, and light oils recovered from the gas are processed for disposition as by-products. The general operation of the process is outlined below. A flow chart for this plant is shown in Figure 1.

#### Carbonisation

The Ford Motor Company By-Product Coke Plant uses the Koppers-Becker type of regenerative coke oven. As previously stated, these are arranged in three blocks of 61 ovens each. The ovens are 42 feet long, 13 ft. 3 in. high, and tapering in width from 16" to 19", to facilitate removal of coke. The individual ovens are separated by walls which contain the vertical heating flues. Characteristics of this type of oven are the individual control and the heating conditions in each flue through separate means of adjustment of the fuel gas, air supply, and draft with the individual regenerators introducing heated air directly at the base of each individual heating flue.

Mixed and crushed coal is delivered to storage bins above each block of ovens. A Larry car is filled from the storage bins and moved into position above the oven to be charged. After the oven is charged and the doors are sealed, enriched blast furnace gas and air are preheated by passing through regenerator checker work below the flues. The mixture is then introduced into the bottom of the flue in alternate pairs of walls. Combustion takes place and the hot gases are drawn by the stack draft across the top of the ovens down through the flues in the adjoining walls and through the checkers which

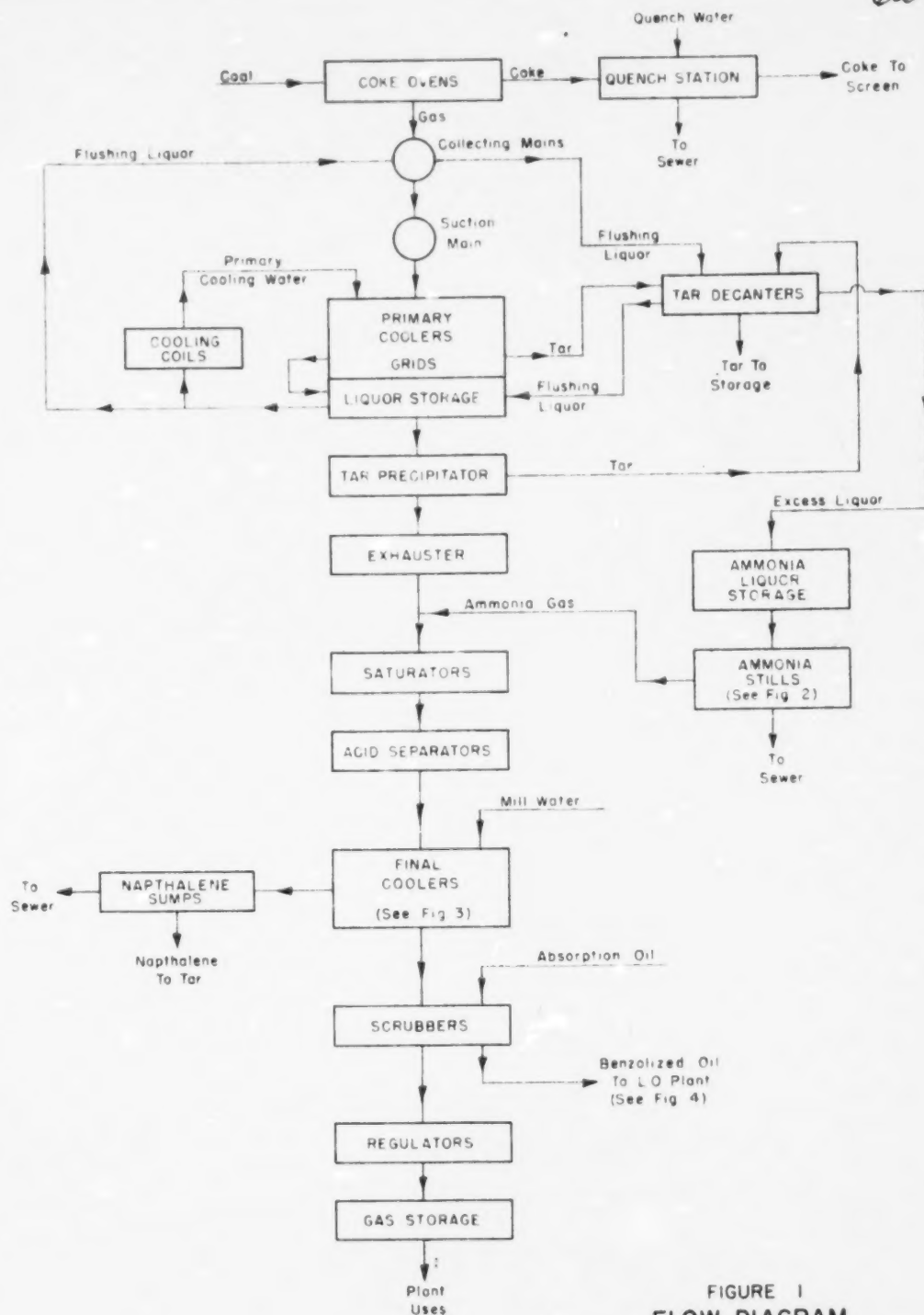


FIGURE 1  
 FLOW DIAGRAM  
 BY-PRODUCT COKE PLANT  
 FORD MOTOR COMPANY  
 DEARBORN, MICH.

FEDERAL SECURITY AGENCY  
 PUBLIC HEALTH SERVICE  
 ENVIRONMENTAL HEALTH CENTER  
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recover most of the waste heat. At one-half hour intervals the flow is automatically reversed so that the fuel gas and the air pass through the hot checkers and the waste gas passes through and heats the cold ones. Coke oven gas, which may be used when blast furnace gas is not available, is not preheated since, because of its higher heat value, a smaller volume is used.

Temperature is controlled by changing the volume of gas in air according to fuel value. Temperature of each flue is checked with an optical pyrometer once each eight hour shift. Under normal conditions of operation coking time is 16 hours 16 min. at a temperature of 2300-2400° F. for production of blast furnace coke, and 32 hours 32 min. at a temperature of 2000-2100° F. for production of foundry coke. During the present survey coking time for all ovens was 32 hours 32 minutes at an average temperature of 2016° F. both types of coke being produced under these conditions.

#### Quenching and Coke Handling

When carbonization is complete the incandescent coke is pushed out of the oven with a ram, operated by a mechanical pusher, through a coke guide on the opposite end of the oven and into the quenching car. The quenching car is then run to the quenching stations and then to a wharf where quenched coke is dumped. The control for starting the push is located in the quenching car and safety devices are provided so that the pusher will not operate unless it is on the same oven as the guide and quenching car. Each block has a pusher and a guide but all three blocks are serviced by one quenching car.

The amount of water used per quench must be just sufficient to quench the coke without leaving it wet. About 750,000 gallons per day are used for this purpose under normal conditions. Water runoff is passed through

settling basins to reclaim coke breeze washed away during the quench.

Quench water is discharged to the tailrace outlet.

#### Gas Collection

Volatile materials and gases released from the coal mix during the coking period are conducted through standpipes into the collector main. A slight pressure condition is maintained in the ovens and in the collector main by an Askania controller, which opens a butterfly valve when the pressure exceeds 1/2 inch of water. The standpipes are provided with dampers by which they may be cut off from the collector main, and with lids which may be opened to allow oven gases to bleed into the air. A steam jet siphon on each standpipe exhausts the oven gases into the collector main against the main pressure while the oven is being charged. Other steam jets are provided to aid in cleaning carbon and tar deposits from clogged standpipes.

Inner surfaces of the standpipe downtakes and collector main are sprayed continuously with "flushing liquor" which removes most of the tar and solid materials carried over from the carbonizing coke in the ovens. This liquor, which consists of water that has picked up ammonia, tar and suspended materials from the gas, flows to the by-products recovery plant, and, after tar and suspended materials have been recovered from it by gravity, is recirculated to the standpipes and collector main through the "flushing liquor" tank.

#### Primary Cooling

Gas from ovens is drawn by vacuum exhausters through primary coolers in which the temperature of the gas is reduced to 90-95° F. The gas enters at the bottom of the cooler and passes upward through "primary cooler liquor" which is washing down over wooden grids. This liquor, consisting essentially of water which has previously picked up ammonia from the gas, removes suspended

tar from the gas and carries it down into a chamber immediately below the grids where the tar settles and is removed continuously through seal-pots, being run into the tar decanters. The liquor overflows from this chamber into the "flushing liquor" tank beneath the primary coolers, from which the necessary volume is recirculated as "primary cooler liquor," being passed through water-cooled coils to maintain its temperature at 90-93° F. at entrance to the primary cooler. An arrangement is available whereby "primary cooler liquor" may be recirculated directly from the bottom of the primary cooler, before this liquor overflows into the "flushing liquor" tank. This system was not in use during the present survey.

The "flushing liquor", carrying tar washed from gas in the oven standpipes and from the collector main, flows from the collecting main into the tar decanter, where the tar settles to the bottom. The tar is removed from the bottom of the decanters and goes to tar storage tanks for ultimate disposal elsewhere.

"Flushing liquor" overflows from the decanter into the "flushing liquor" tank and is then recirculated to the standpipe downtakes and collector main without further cooling. The temperature is 170-175° F.

Surplus liquor from the "flushing liquor" tank goes to ammonia liquor storage tanks for subsequent by-product recovery in the ammonia stills.

It may be noted that the designations "flushing liquor," "primary cooling liquor," and "ammonia liquor," all are used in referring to the same liquid. The nomenclature used in a particular case refers to the use to which the liquor is put.

#### Precipitator and Exhausters

The gas is passed through the precipitator where finely dispersed tar is removed in a high-tension electrically charged field. The tar is removed through a seal and goes into the decanter. From the precipitator the gas

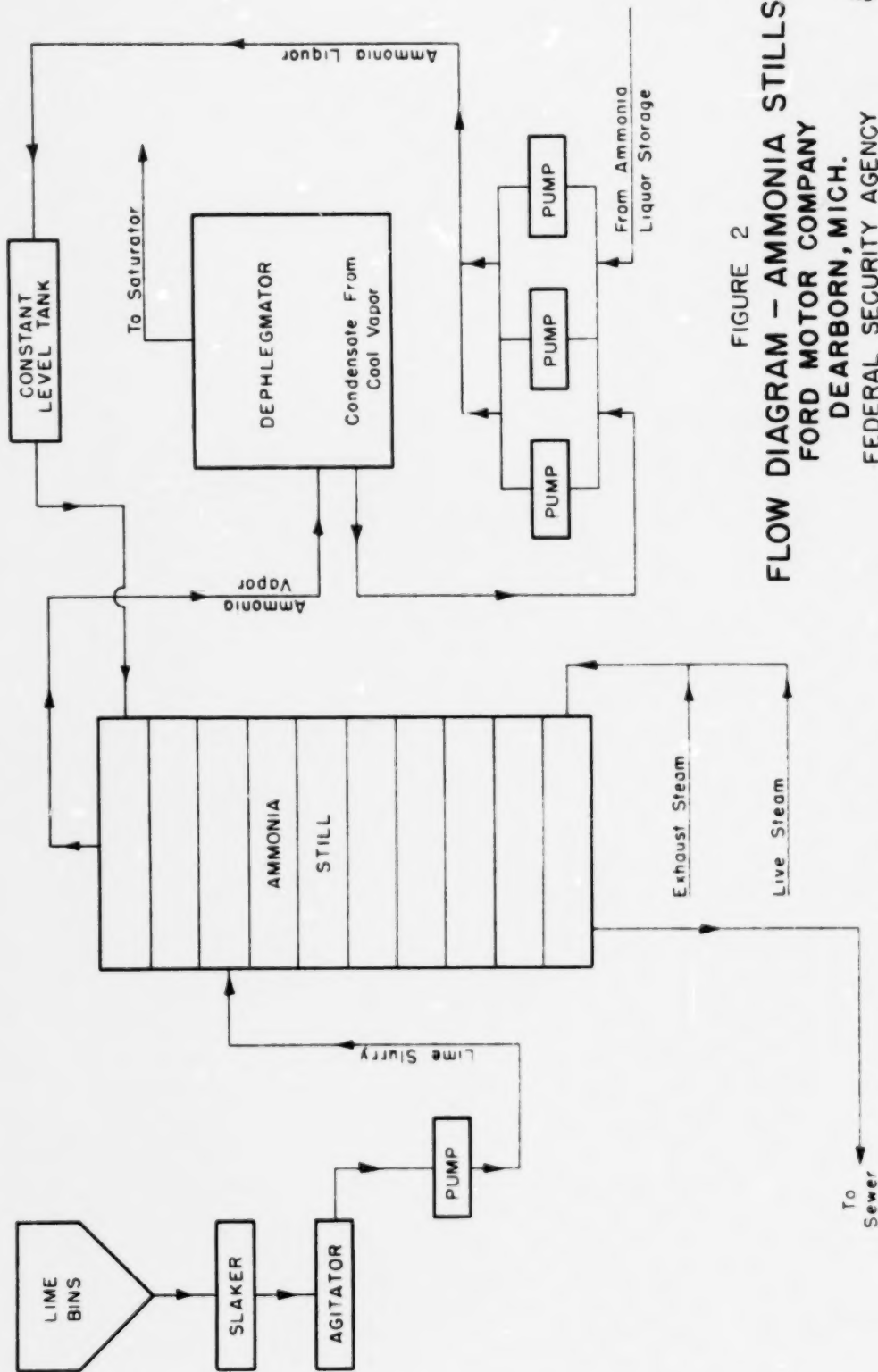


FIGURE 2

# FLOW DIAGRAM - AMMONIA STILLS FORD MOTOR COMPANY DEARBORN, MICH.

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CINCINNATI, OHIO      OCTOBER, 1949

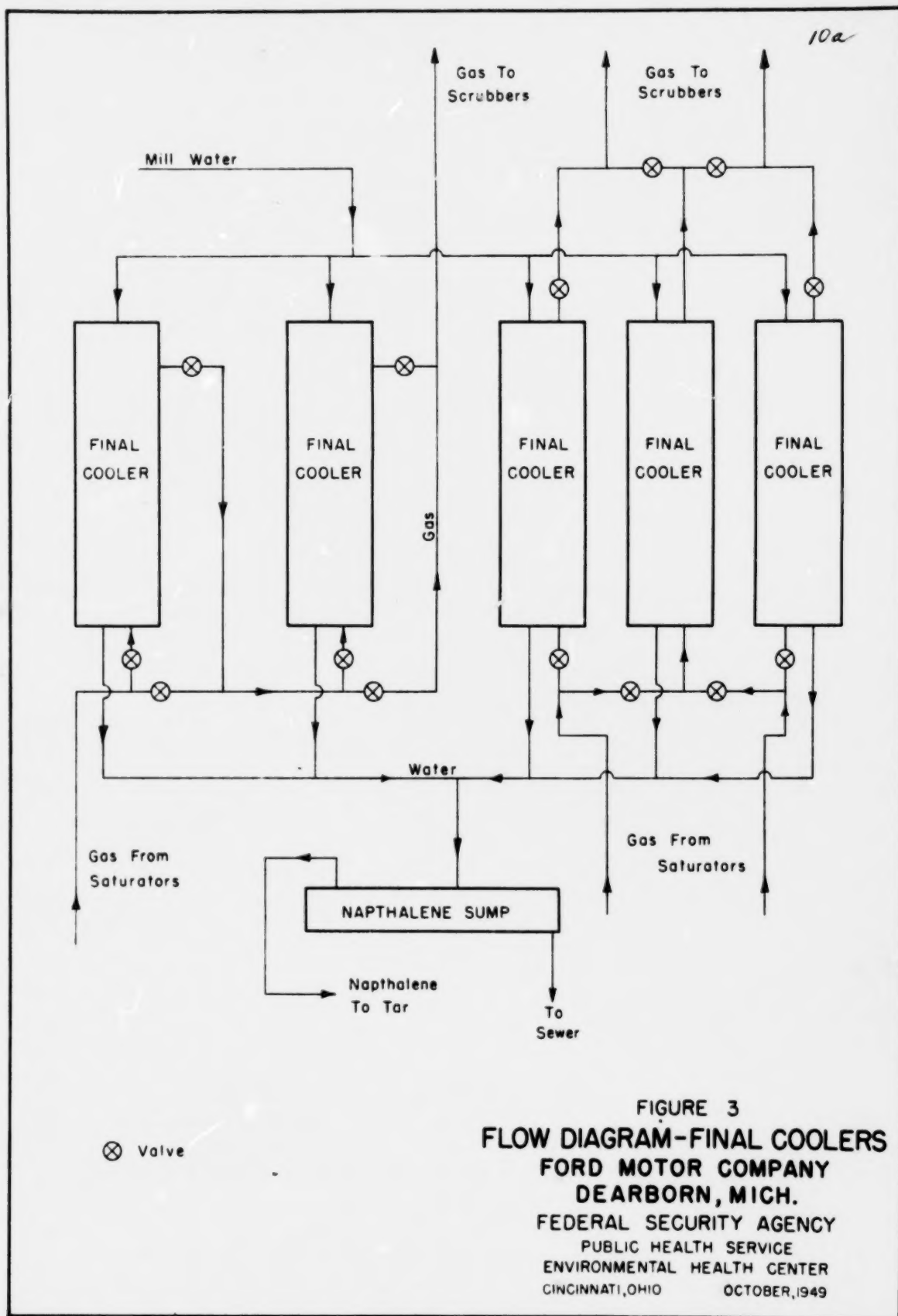
passes through the exhausters. These are centrifugal compressors which maintain a vacuum of 11 to 11-1/2 inches of water on the gas from the ovens and provide a pressure of 3-1/2 to 4-1/2 inches of mercury on the gas leaving the exhausters. This pressure serves to force the gas through the cleaning processes which follow and finally into the gas holder.

#### Ammonia Recovery

Ammonia from the surplus primary cooler liquor is recovered by steam distillation and added to the gas coming from the exhausters (See Figure 2). Quick lime is mixed with enough water to give an easily handled suspension and introduced into the third ring of the still to release fixed ammonia. Wastes from the still are checked three times a day and the amount of lime varied in such a manner that free lime and ammoniac salts are held to a minimum.

#### Saturators

Oven gas plus the recovered ammonia is sent to the sulfuric acid saturator to remove ammonia by the formation of ammonium sulfate. The gas enters the bottom of the saturating zone and passes upward through a spray of 5-6% sulfuric acid, which reacts with the ammonia in the gas to form ammonium sulfate. Liquor containing the ammonium sulfate crystals condenses in the bottom of the saturator. The upper layer overflows into the mother liquor tank while the lower layer of this liquor, having a higher concentration of ammonium sulfate, is pumped to elevated holding tanks. The sulfate crystals settle to the bottom of these tanks, and this concentrated sulfate solution is run onto rotating vacuum filters. Overflows are provided in the holding tanks for running the clear liquor back into the mother liquor tank. Hot air is continuously drawn through the vacuum filters and the action of this, together with the vacuum



being exerted on the slurry, results in the separation of the liquid from the crystals, and the production of dry ammonium sulfate. The dried salt is automatically scraped from the surface of the filters by a knife edge which immediately precedes the point of application of the salt slurry to the filter. The dried salt falls onto a belt conveyor which conducts it into the sulfate storage room where it is weighed and packed for sale. Liquor obtained as a result of the drying process is run back into the mother liquor tank. The contents of the mother liquor tank are recirculated as a spray into the saturating zone. Acid strength is maintained by the addition of 60° Be  $H_2SO_4$  to the mother liquor tank as required, acid concentration being checked every half-hour. The acid consumption is recorded daily and compared with salt production. Each pound of acid makes about one pound of dried salt.

#### Acid Separators

The gas passes through acid separators to remove entrained sulfuric acid. The separator is of the baffle type in which the gas stream is caused to change direction sharply many times, depositing the suspended acid on the baffles. Reclaimed acid is returned to the mother liquor tank.

#### Final Coolers

The gas from the acid separators flows to the final coolers for removal of the naphthalene (See Figure 3). It passes upward through water washing down over wooden grids and is cooled to less than 85° F.

The naphthalene separates out and is carried down by the cooling water into sumps where it collects on the surface of the water. Naphthalene is removed at intervals, drained and mixed with the tar. During the winter when colder water is available the temperature of the gas at the top of the cooler may drop as low as 45° F. This is considered satisfactory so long as no appre-

ciable amount of light oil is removed with the naphthalene. The light oil content of the gas is checked before and after the cooler in order to hold the loss to a minimum.

### Scrubbers

From the final coolers the gas passes to the scrubbers where the light oil is removed by counterflow scrubbing with absorption oil. The latter is a high boiling paraffin oil in which the light oil contained in the gas dissolves and can be removed by subsequent steam distillation. Temperature of the gas to the scrubbers is not lower than 60° F. and the absorption oil temperature is kept at around 65° F. From the scrubbers the gas passes to the holder for storage and distribution. The gas going to the holder is mixed with Blast Furnace Gas to maintain a heating value of 490 B.T.U./cubic foot, when corrected to standard conditions. Coke oven gas to the ovens has a heat value of 520-540 B.T.U./cubic foot depending on coal mix, coking time, and temperature required.

### Light Oil Recovery

The Light Oil Recovery Plant is shown diagrammatically in Figure 4.

The absorption oil containing the light oil picked up from the gas is preheated to a temperature of 248° F. by passage through heat exchangers, and steam distilled. Both exhaust and live steam are used for this purpose. The light oil escapes from the top of the still in the vapor state, while the now debenzolized absorption oil comes from the bottom of the still, runs into a decanter for removal of entrained water, and, following cooling, is recirculated to the scrubbers. The light oil vapor, after passing through the heat exchangers, enters the bottom of the dephlegmator and during passage

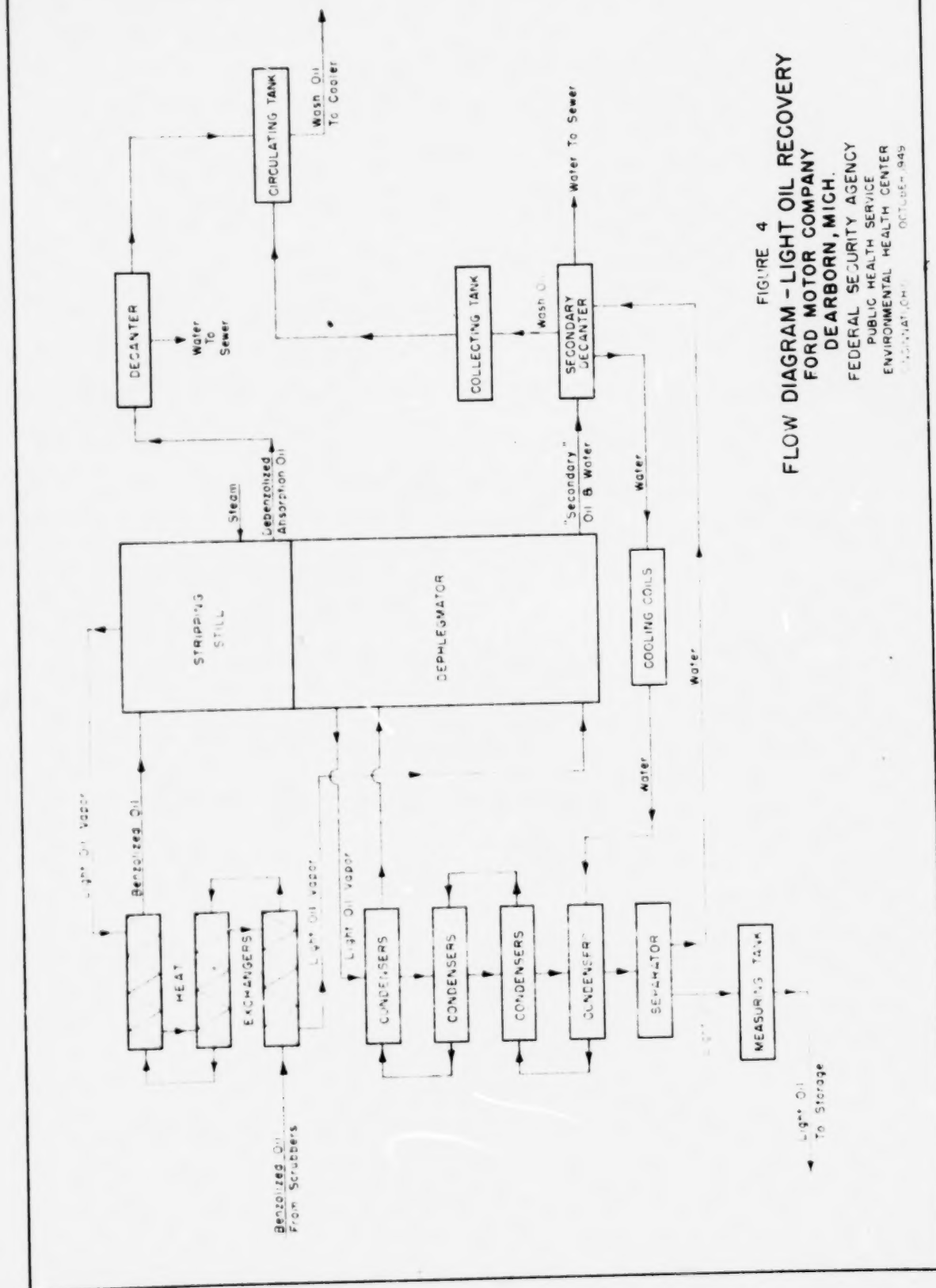


FIGURE 4  
 FLOW DIAGRAM - LIGHT OIL RECOVERY  
 FORD MOTOR COMPANY  
 DEARBORN, MICH.  
 FEDERAL SECURITY AGENCY  
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 WASHINGTON, D.C. OCTOBER 1949

through this unit is cooled to a temperature of 95° C. The cooled vapor comes off the top of the still, while "secondary" wash oil (the lower boiling fractions of the absorption oil) is removed from the bottom. This latter oil flows through the "secondary decanter" where entrained water is removed, some of which is cooled and recirculated through light oil condensers, while the excess is discharged to the sewer. The "secondary" wash oil is returned to the debenzolized absorption oil tank for recirculation to the scrubbers. The light oil vapor from the dephlegmator passes through a series of condensing coils, in which it is progressively cooled. Upon leaving the condensing coils the light oil, now in liquid form, is separated from any water which may have carried over with it. This water goes to the secondary decanter. The volume of crude light oil obtained is measured, after which the light oil goes to storage.

Approximately 50 percent of the crude light oil produced is refined by washing with a weak sulfuric acid solution, followed by a water rinse, and a caustic soda wash. This is an intermittent operation, and very small volumes of washing solutions are used.

Light oil is sold without restriction except that it must be reasonably free from absorption oil. An average analysis of the light oil sample runs as follows:

|                                                     |             |
|-----------------------------------------------------|-------------|
| Benzene                                             | 70-80%      |
| Toluene                                             | 5-15%       |
| Xylol                                               | 1-2%        |
| Forerunnings, Unsaturates,<br>and High Boiling Ends | Balance     |
| Specific Gravity                                    | .880 - .885 |

### Tar Disposal

Tars collected in the decanter are sent to storage for sale to Barrett Division for processing. This tar must not contain more than 5% moisture, must have a specific gravity of approximately 1.2, and a naphthalene content of approximately 10%. If the acid content of the tar is less than .5% it may be used for fuel, depending on the relative market value of tar and fuel oil but if the acid content exceeds .5% it is sold to processors for recovery of tar acids.

### Control Tests

Control tests are made at regular intervals to insure efficient and economical operation of recovery units. The following conditions should be maintained:

Gas to the precipitator must contain less than 1 grain tar/cubic foot and gas leaving precipitator less than .02 grain/cubic foot. Gas leaving the acid saturator shall contain less than 2 grams  $\text{NH}_3$ /1000 cubic feet (Ammonia content of raw gas is approximately 200 grams/1000 cubic feet).

Waste from the ammonia recovery still must contain not more than 0.5 gram  $\text{NH}_3$ /liter, and must contain free lime, but not more than 1 gram  $\text{CaO}$ /liter.

Dried ammonium sulfate must contain at least 25.25%  $\text{NH}_3$ , not more than 0.15% sulfuric acid and not more than 0.25% moisture.

Light oil loss through the final coolers must be less than 0.3 gallon oil/10,000 cubic feet of gas and light oil content of gas after the scrubbers must not exceed 0.3 gallon/10,000 cubic feet except in summer when it is allowed to go as high as 0.6 gallon/10,000 cubic feet. Debenzolized absorption oil from the light oil still must not contain more than 0.1% light oil.

Additional tests may be made when necessary.

## SURVEY PROCEDURES

### Sample Collection

Samples were taken of mill water, ammonia still influent and effluent, final cooler effluent, and secondary decanter effluent.

All samples were collected by Ford Motor Company personnel. Equal portions of sample were taken at half-hour intervals over each 24-hour sampling period and composited. Approximately five gallons of sample was obtained at each sampling point. This was divided between the laboratories of the Ford Motor Company and the Public Health Service for duplicate analyses.

Mill water samples were obtained from a tap in the by-products building. Ammonia still influent was obtained from a petcock on the pumps which fed the still, while effluent samples were taken from a tap on the discharge line. Final cooler effluent was obtained from the effluent channel preceding the naphthalene sumps. Secondary decanter effluent was obtained from the standpipe into which the waste was discharged.

### Hydraulic Measurements

#### A. Ammonia Still

Flow measurements of still discharge could not be obtained either by direct measurement or by calculation. Liquor entering the still is increased in volume during passage through the still due to water added in the lime slurry, and condensation of steam. This increase has been taken as being 20% of the influent volume, which, it is felt, is a conservative estimate.

#### B. Final Coolers

Measurement of final cooler discharge was made by rod-suspended current meter readings, in the effluent channel preceding the naphthalene sumps. Flow from these units was essentially constant during the survey.

### C. Secondary Decanter

Discharge from these units had to be obtained by an indirect method, due to the inaccessibility of the discharge point. The flow was measured by closing all outlets from the unit and measuring the quantity of oil displaced into a measuring tank in a known time. Since this oil was displaced by water which would otherwise have been discharged to the sewer, the amount of waste discharged was obtained. This procedure interfered to some extent with plant operation and was carried out only once.

### D. Mill Water

Knowledge of mill water flow was required only for the final coolers. Measurement was not necessary, as final cooler flow was determined as described above.

### Laboratory Procedures

The following determinations were made on the samples collected:

- Phenol
- Cyanide
- Ammonia
- pH
- 5-Day B.O.D.
- Total Sulfur
- Alkalinity
- Total Solids, total and volatile
- Suspended Solids, total and volatile

In general the procedures followed were as given in "Standard Methods for the Examination of Water and Sewage," 9th edition (1). Modifications were made in the procedures for phenol, cyanide, and total sulfur. These modifications will be found in Appendix A.

## EXPLANATION OF ANALYSES

### Phenols

The results, as reported, show the gross phenol content, including cresols and higher phenols. These substances are found in variable proportions and amounts in certain types of industrial wastes. These substances may result, as in by-product coke and gas plant wastes, from the pyrolysis of organic material producing phenols.

Phenols in quantities of 0.002 to 0.005 part per million in the presence of chlorine will produce chlorophenol (medicinal) tastes and odors in water. A concentration of 0.1 part per million of phenol alone imparts to water the characteristic taste and odor of phenol. In fish, phenol produces paralysis of the neuromuscular mechanism and hemolyzes the blood. Experiments have shown that concentrations as low as 5 parts per million will kill trout in less than 24 hours. It has further been found that fish react positively toward phenol - that is, they tend to swim toward higher concentrations (2).

### Ammonia

The results, as reported, show the free ammonia and ammonium salts. They do not include albuminoid ammonia and organic nitrogens.

Ellis and Chipman (1936) in their experiments on toxicity of ammonia and its compounds to fish determined that pH is a large factor in regulating the toxicity of such substances. It was found that the toxicity of ammonium compounds increased 200 percent or more between pH 7.4 and 8.0. The lower limits of toxicity (death in 10 days or less, depending upon conditions of the experiments) was found to be near 2.5 parts per million of ammonia within the pH range stated (3).

In a water supply the presence of free ammonia in excessive amounts in-

icates adjacent or recent pollution. In the treatment of water supplies ammonia tends to combine with the chlorine added, forming chloramines. The sterilizing action of the chlorine is retarded and larger doses are necessary to maintain required residuals. Erratic chlorine demand constitutes a public health hazard.

#### Cyanides

The test for cyanides is reported in terms of HCN but it includes various cyanide salts as well as the HCN. Cyanide is one of the most toxic substances in industrial wastes. Low concentrations are fatal to fish. Ellis reports that concentrates of 0.1 to 0.3 part per million KCN killed gold fish in hard water within 3 to 4 days (4).

#### pH Value

The symbol "pH" denotes the logarithm of the reciprocal of the hydrogen ion concentration in a given water, this symbol being a universal one in chemistry. The pH-value indicates the relative acidity or alkalinity of a water or waste, being lower with higher degrees of acidity. It is a measure of intensity rather than of quantity.

#### Alkalinity or Acidity

Alkalinity of a water or waste represents its content of carbonates, bicarbonates, hydroxides, and very occasionally borates, silicates, and phosphates of the alkali and alkali earth metals. Calcium and magnesium are the two metals which account for most of the alkalinity. Acidity of a water represents the content of free carbon dioxide, mineral acids, and salts which hydrolyze to give hydrogen ions. The results for alkalinity or acidity are expressed as parts per million of calcium carbonate ( $\text{CaCO}_3$ ).

### Biochemical Oxygen Demand (B.O.D.)

The biochemical oxygen demand of sewage, polluted water, or industrial waste is the amount of oxygen required during stabilization of the organic matter by aerobic bacterial action. Since this is a phenomenon into which both time and temperature enter, a standard set of conditions (5 days, 20°C) is universally used for the test. For normal domestic sewage and some industrial wastes approximately 68 percent of the oxygen requirement of the carbonaceous material present is normally satisfied during the standard test. For industrial wastes with certain characteristics different from domestic sewage this percent satisfied during the test may differ considerably.

### Solids

Solids analyses include total solids, suspended solids, and the volatile constituents of each. Total volatile and suspended solids data for domestic sewage have a defined relationship to B.O.D. values and may be used for comparative purposes. Solids data for industrial wastes, however, seldom show a like relationship and are therefore not put on a comparative basis in this report.

### Total Sulfur

Sulfur is found in the wastes from by-product coke plants as hydrogen sulfide, sulfate, thiosulfate, thiocyanate, and carbon bisulfide. Sulfides are important because of their immediate oxygen demand, which depletes the oxygen reserves of any body of receiving water. Sulfur compounds, under anaerobic conditions, are reduced to sulfides, usually in the form of hydrogen sulfide, which create other nuisances and are corrosive.

### DISCUSSION OF RESULTS

Operations at the Ford Motor Company by-product coke plant are reasonably constant during each day. The amount of by-product and the strength of the wastes are affected mainly by the quality of the coal used, the coking time, and temperature. Both blast furnace (85% high volatile, 10% low volatile, 5% anthracite) and foundry (50% high volatile, 50% low volatile) types of coke were being produced during this survey. Coking times and temperatures were the same for both types of coke.

The following table of coal consumption and production of finished products is given as an aid in the interpretation of the analytical results of this survey:

| <u>Date</u> | <u>Coal<br/>Carbonized<br/>(tons)</u> | <u>Gas Prod.<br/>(1000 cu.ft.)</u> | <u>Light Oil<br/>(Gallons)</u> | <u>Ammonium<br/>Sulfate<br/>(pounds)</u> |
|-------------|---------------------------------------|------------------------------------|--------------------------------|------------------------------------------|
| 10/23-24    | 2130                                  | 23,045                             | 4790                           | 34,966                                   |
| 10/24-25    | 2170                                  | 23,368                             | 4560                           | 41,340                                   |
| 10/26-27    | 2185                                  | 23,242                             | 4823                           | 35,975                                   |
| 10/30-31    | 2298                                  | 23,412                             | 5130                           | 48,770                                   |
| 10/31-11/1  | 2307                                  | 23,469                             | 5240                           | 57,240                                   |
| 11/2-3      | <u>2309</u>                           | <u>23,476</u>                      | <u>5380</u>                    | <u>63,600</u>                            |
| Avg.        | 2233                                  | 23,335                             | 4987                           | 46,982                                   |

Average coking temperature 2016° F.

Average Coking Time ~ 32 Hr. 32 min.

The results of the analyses and the amounts of the various polluting substances are discussed below. These data are shown in tabular form in Tables 1 through 3, Appendix B.

Discharge

Discharge volumes from the units studied were:

|               | <u>Million gal. per day</u> |             |             |
|---------------|-----------------------------|-------------|-------------|
|               | <u>Average</u>              | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still | 0.071                       | 0.085       | 0.052       |
| Final Cooler  | 5.4                         | "           | "           |
| Sec. Decanter | 0.045                       | "           | "           |

Ammonia still discharge was not constant but was found to vary each day. Factors responsible for this variation are: (1) difference in amount of still feed; (2) variation in amount of steam condensation; (3) variation in volume of lime slurry added.

Final cooler discharge was constant throughout the sampling period.

As previously mentioned, secondary decanter discharge was measured only once, but was stated to be reasonably constant.

Secondary Decanter

The major source of waste materials from this plant were the ammonia stills and final coolers.

The secondary decanter was found to be an insignificant contributor of pollution to the tailrace outlet.

For this reason, wastes from this unit are not considered in the following discussions, but are listed in Tables 1 and 2, Appendix B, for reference.

Phenol

Concentration and quantity of phenol was found to be as follows:

|               | <u>ppm</u>   |             |             | <u>Pounds per day</u> |             |             |
|---------------|--------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Aver.</u> | <u>Max.</u> | <u>Min.</u> | <u>Aver.</u>          | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |              |             |             |                       |             |             |
| Influent      | 1210         | 1560        | 878         | 595                   | 923         | 383         |
| Effluent      | 852          | 1170        | 649         | 507                   | 828         | 323         |
| Final Cooler  | 3.8          | 4.7         | 3.3         | 172                   | 211         | 150         |

Phenol concentration was highest in the ammonia still waste, being approximately 300 times as great as that in the final cooler discharges. On a poundage basis, however, this ratio was of the order of 3 to 1, due to the much greater volume of final cooler waste.

The average discharge of phenol from the ammonia still was 507 pounds per day, and from the final coolers was 172 pounds per day; 679 pounds of phenol was thus entering the tailrace outlet from the coke plant. Inasmuch as 4 pounds of phenol was present in mill water entering the final coolers, the pick-up of phenol due to final cooling was 168 pounds. Coke plant operations therefore produced 675 pounds of phenol per day, of which 75% came from the ammonia still, the remaining 25% from final coolers.

It may be noted that 15% of the phenol in the ammonia liquor was removed during passage through the still and returned to the gas stream. This is most probably picked up by the final cooler water and discharged in this latter waste.

#### Cyanide

Cyanide, as HCN, was found as follows:

|               | <u>ppm</u>   |             |             | <u>Pounds per day</u> |             |             |
|---------------|--------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Aver.</u> | <u>Max.</u> | <u>Min.</u> | <u>Aver.</u>          | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |              |             |             |                       |             |             |
| Influent      | 118          | 153         | 66          | 54                    | 90          | 36          |
| Effluent      | 1.9          | 3.4         | 0.4         | 1.1                   | 2.2         | 0.3         |
| Final Cooler  | 27           | 34          | 22          | 1220                  | 1540        | 980         |

A total of 1220 pounds of cyanide is discharged to the tailrace outlet from the coke plant. As no cyanide is present in the incoming mill water, the entire amount is chargeable to the plant. Practically all of this cyanide, 99% of the total, is present in the discharge from the final coolers. Although a fair amount of cyanide is found in the ammonia still influent, only a very small quantity is discharged from this unit, 98% being removed in passage through the still.

Ammonia

Ammonia, as  $NH_3$ , was present as follows:

|               | <u>BPM</u>   |             |             | <u>Pounds per day</u> |             |             |
|---------------|--------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Aver.</u> | <u>Max.</u> | <u>Min.</u> | <u>Aver.</u>          | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |              |             |             |                       |             |             |
| Influent      | 12,600       | 13,200      | 12,100      | 6180                  | 7610        | 4330        |
| Effluent      | 1,370        | 1,750       | 804         | 820                   | 1120        | 415         |
| Final Coolers | 3.8          | 10.2        | 0.0         | 171                   | 459         | 0           |

A total of 991 pounds of ammonia (as  $NH_3$ ) is discharged from the plant per day. Of this total 820 pounds, or 82.7% is from the ammonia still while 171 pounds, or 17.3% comes from the final coolers.

Since there are 12 pounds of ammonia (as  $NH_3$ ) in the influent to the final coolers, 159 pounds is due to operation of these units. This leaves a total of 979 pounds chargeable to the plant, 83.6% of this coming from the ammonia still, 16.2% from the final coolers.

87% of the ammonia in the weak liquor was removed in the ammonia still and introduced into the gas going to the saturators.

5-day B.O.D.

Concentration and quantity of 5-day B.O.D. were as follows:

|               | <u>BPM</u>   |             |             | <u>Pounds per day</u> |             |             |
|---------------|--------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Aver.</u> | <u>Max.</u> | <u>Min.</u> | <u>Aver.</u>          | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |              |             |             |                       |             |             |
| Influent      | 3880         | 5020        | 2220        | 1900                  | 2950        | 953         |
| Effluent      | 2110         | 3200        | 1320        | 1270                  | 2270        | 570         |
| Final Coolers | 425          | 561         | 320         | 19,100                | 25,200      | 14,400      |

Total quantity of 5-day B.O.D. discharged from these units was 20,400 pounds per day. Of this total 6.2% came from the ammonia still, while the remaining 93.8% was in the final cooler effluent. The latter value is significant when considering recirculation of final cooler water.

An average of 91 pounds per day of 5-day B.O.D. was present in the mill water entering the final coolers. This leaves 19,000 pounds per day of 5-day B.O.D. due to final cooler wastes. A total of 20,300 pounds per day of 5-day B.O.D. therefore results from plant operations. Of this total, ammonia still contributes 6.3%, final cooler 93.7%.

The 5-day B.O.D. of the weak ammonia liquor was reduced by 33% in passage through the still.

#### Total Sulfur

Sulfur, as total sulfur, was found as follows:

|               | <u>ppm</u>  |             |             | <u>Pounds per day</u> |             |             |
|---------------|-------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Avg.</u> | <u>Max.</u> | <u>Min.</u> | <u>Avg.</u>           | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |             |             |             |                       |             |             |
| Influent      | 1680        | 2100        | 1280        | 807                   | 910         | 663         |
| Effluent      | 920         | 1000        | 771         | 543                   | 699         | 392         |
| Final cooler  | 18          | 31          | 4           | 790                   | 1390        | 180         |

1333 pounds per day of sulfur were discharged into the tailrace outlet. Of this total, 543 pounds or 40.7% was found to be in the ammonia still effluent, while 790 pounds or 59.3% was in the final cooler discharge.

Since 279 pounds of sulfur were in the final cooler influent water, only 511 pounds were added in the final cooler. This leaves a total of 1054 pounds of sulfur produced by the plant, 51.5% by the ammonia still, 48.5% by the final cooler.

#### Total Solids

|               | <u>ppm</u>  |             |             | <u>Pounds per day</u> |             |             |
|---------------|-------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Avg.</u> | <u>Max.</u> | <u>Min.</u> | <u>Avg.</u>           | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |             |             |             |                       |             |             |
| Influent      | 14,700      | 16,700      | 13,300      | 7,280                 | 9,880       | 4,840       |
| Effluent      | 15,900      | 17,400      | 14,400      | 9,400                 | 11,800      | 6,760       |
| Final cooler  | 193         | 212         | 160         | 8,700                 | 9,540       | 7,200       |

Average pounds of total solids discharged from the ammonia still per day

was 9400, of which 6180, or 66%, were volatile.

From the final cooler were discharged an average of 8700 pounds per day, of which 4080 pounds, or 47%, were volatile. Since there were present in the mill water entering the final coolers an average of 7110 pounds of total solids, there is chargeable to this operation only 1590 pounds per day, of which 730 pounds, or 46%, were volatile.

Combined discharge of total solids to the tailrace amounted to 18,100 pounds, of which 10,260 pounds, or 57%, were volatile. Total solids directly chargeable to coke plant operation amounted to 11,000 pounds per day, of which 6910 pounds, or 63%, were volatile.

#### Suspended Solids

|               | <u>ppm</u>  |             |             | <u>Pounds per day</u> |             |             |
|---------------|-------------|-------------|-------------|-----------------------|-------------|-------------|
|               | <u>Avg.</u> | <u>Max.</u> | <u>Min.</u> | <u>Avg.</u>           | <u>Max.</u> | <u>Min.</u> |
| Ammonia Still |             |             |             |                       |             |             |
| Influent      | 40          | 51          | 30          | 20                    | 28          | 14          |
| Effluent      | 880         | 1640        | 404         | 620                   | 1610        | 198         |
| Final Cooler  | 25          | 35          | 13          | 1120                  | 1570        | 585         |

The average amount of suspended solids discharged from the ammonia still was 620 pounds per day, of which 189 pounds per day, or 31%, were volatile.

Suspended solids in the final cooler discharge averaged 1120 pounds per day of which 525 pounds per day, or 46.9%, were volatile. Since there were 608 pounds per day of suspended solids in the mill water, of which 191 pounds were volatile, the addition of 510 pounds of suspended solids, of which 334 pounds, or 65%, were volatile, is attributable to final cooler operation.

Suspended solids due to plant operation therefore totaled 1130 pounds per day, of which 523 pounds, or 46%, were volatile.

#### pH

Average pH values for the various liquors were as follows:

|               |      |
|---------------|------|
| Ammonia Still |      |
| Influent      | 10.1 |
| Effluent      | 8.5  |
| Final Cooler  | 7.6  |

### Total Alkalinity

Average alkalinities were found to be:

|               |            |
|---------------|------------|
| Ammonia still |            |
| Influent      | 22,000 ppm |
| Effluent      | 900 ppm    |
| Final Cooler  | 95 ppm     |

### Summary

On the basis of the data and supporting information presented in this report, certain pertinent points may be summarized as follows:

(a) Quantities of significant constituents in the wastes discharged daily from this by-product coke plant under the operating conditions prevailing during the survey are as follows:

|                          | <u>Total in<br/>effluent</u> | <u>In mill<br/>water</u> | <u>Chargeable<br/>to plant</u> |
|--------------------------|------------------------------|--------------------------|--------------------------------|
| Phenol                   | 679                          | 4                        | 675                            |
| Cyanide as HCN           | 1220                         | 0                        | 1220                           |
| Ammonia as $\text{NH}_3$ | 991                          | 12                       | 979                            |
| 5-day B.O.D.             | 20,400                       | 91                       | 20,300                         |
| Suspended solids         | 1,740                        | 603                      | 1,130                          |

(b) Unit values for wastes and constituents from carbonization of

one ton of coal are as follows:

|                          |            |
|--------------------------|------------|
| Final coolers            | 2420 gal.  |
| Ammonia still wastes     | 31.8 gal.  |
| Phenols                  | 0.30 pound |
| Ammonia as $\text{NH}_3$ | .44 pound  |
| Cyanides as HCN          | 0.55 pound |
| 5-Day B.O.D.             | 9.1 pound  |

(c) The average yield of coke and by-products from carbonization of one ton of coal is as follows:

|                  |                |
|------------------|----------------|
| Coke             | 1550 pounds    |
| Ammonium sulfate | 19.7 pounds    |
| Gas              | 10,400 cu. ft. |
| Tar              | 7.8 gal.       |
| Light Oil        | 2.2 gal.       |

This is comparable to the average yield of coke and by-products from similar plants (6).

(d) Major sources of waste products from the coke plant are the ammonia stills and the final cooler effluent.

## COMPARISON OF RESULTS WITH THOSE OF PREVIOUS SURVEY

During the period Dec. 7-12, 1947, a survey similar to the one heretofore discussed was carried out at this plant by the Public Health Service. The most important information from both of these surveys is tabulated below for comparative purposes:

|                                                   | <u>Dec. 7-12, 1947</u> | <u>Oct. 23-Nov. 3, 1949</u> |
|---------------------------------------------------|------------------------|-----------------------------|
| Tons coal carbonized daily                        | 4515                   | 2233                        |
| Coking temperature                                | 2253 °F                | 2016 °F                     |
| Coking time                                       |                        | 32 hrs. 32 min.             |
| <u>Waste Flow/Ton Coal Carbonized</u>             |                        |                             |
| Final coolers                                     | 1330 gal.              | 2420 gal.                   |
| Ammonia still                                     | 18.5 gal.              | 31.8 gal.                   |
| <u>Waste constituents per ton coal carbonized</u> |                        |                             |
| Phenol                                            | 0.14 lb.               | 0.30 lb.                    |
| Ammonia as NH <sub>3</sub>                        | 1.2 lb.                | 0.44 lb.                    |
| Cyanide as HCN                                    | 0.76 lb.               | 0.55 lb.                    |
| 5-Day B.O.D.                                      | 6.1 lb.                | 9.1 lb.                     |
| <u>By-Products Recovered/Ton Coal Carbonized</u>  |                        |                             |
| Coke                                              | 1500 lb.               | 1550 lb.                    |
| Ammonium Sulfate                                  | 14.5 lb.               | 19.7 lb.                    |
| Gas                                               | 10,100 cu. ft.         | 10,400 cu. ft.              |
| Tar                                               | 8.2 gal.               | 7.8 gal.                    |
| Light Oils                                        | 2.5 gal.               | 2.2 gal.                    |

The amount of coal carbonized daily was roughly half that carbonized during the 1947 survey. Moreover, the average coking temperature was reduced by 237 °F and the coking time increased by 13 hours.

Waste flows per unit of coal carbonized were greater during the 1949 investigation, showing an increase over the 1947 survey of 82% for final cooler flow and 72% for ammonia still discharge.

Waste constituents discharged per ton of coal carbonized were quite different for each of the surveys. In the 1949 survey phenol increased to 0.30 pounds from a value of 0.14 pounds found in 1947. The 5-day B.O.D. also increased to 9.1 pounds from a value of 6.1 pounds. On the other hand, ammonia decreased from 1.2 pounds to 0.44 pound. Cyanide also decreased from 0.76 pounds to 0.55 pounds.

The amounts of by-products recovered per ton of coal carbonized were also found to differ. Coke production increased slightly. Ammonium sulfate production increased to 19.7 pounds in 1949, as contrasted with the figure of 14.5 pounds in 1947. Gas production increased very slightly, being 10,400 cu. ft. in 1949, 10,100 cu. ft. in 1947. Tar production was slightly reduced, from 8.2 gal. to 7.8 gal. Recovery of light oils was also slightly reduced, from 2.5 gal. to 2.2 gal.

These variations conform to the trends determined by U. S. Bureau of Mines investigations (7, 8).

#### ACKNOWLEDGEMENT

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## APPENDIX A

DETERMINATION OF PHENOL

NOTE: This method  
used for  
ammonia still  
influent and  
effluent only

I. Preliminary ScreeningA. Reagents

10%  $\text{CuSO}_4$  solution

10% phosphoric acid solution

Sodium chloride, fine-grained

Chloroform, C.P.

0.1 N NaOH

B. Procedure

1. To 250 ml. of sample add 2 ml. of 10%  $\text{CuSO}_4$  solution and bring the pH of the mixture below 4.0 by the addition of 10% phosphoric acid solution. Put the mixture in an all-glass distillation apparatus. Distill over approximately 200 ml. Halt the distillation, and allow the distilling flask to cool until boiling ceases. Add 50 ml. of distilled water to the distilling flask. Resume the distillation and continue until a total of 250 ml. has been distilled over.
2. Acidify the distillate with 1 ml. of 10% phosphoric acid solution and add 5 ml. of 10%  $\text{CuSO}_4$  solution. Transfer the mixture to a separatory funnel containing 75 grams of fine-grained sodium chloride. Make 3 serial extractions with C.P. chloroform. On the first extraction, shake the mixture until the salt has completely dissolved. Use 50 ml. of chloroform per extraction. Collect the chloroform extract, discarding the aqueous phase after the third extraction. Combine the chloroform extract. Extract the chloroform twice with 75 ml. portions of 0.1 N sodium hydroxide. Discard the extracted chloroform. Combine the alkaline extract and make it up to 250 ml. using a volumetric flask.

## III. Determination of Phenol

### A. Reagents

N/10 sodium bromate-bromide solution: 2.784 g. of pure dry sodium bromate and 10 g. of sodium bromide dissolved in a little water and made up to a liter.  
 Conc. HCl, C.P. KI, N/10 thiosulfate solution.

### B. Procedure

Take an aliquot portion equal to about 0.05 g. phenol. Add 50 ml. of bromate solution and shake. Add 5 ml. of conc. HCl. After 15 min. shake again and add 2 g. of KI. The liberated iodine is titrated in the presence of a starch solution with N/10 thiosulfate, to thiosulfate-starch endpoint.

$$\text{ppm phenol} = \frac{\text{ml. N/10 thio soln.} \times 1.567 \times 1000}{\text{ml. sample used}}$$

## DETERMINATION OF CYANIDE

### I. Preliminary Purification

#### A. Reagents

- 10% NaOH solution
- 5% lead acetate soln.
- 15% Tartaric acid soln.
- 2% NaOH soln.

#### B. Procedure

1. Make a 200 ml. portion of the sample alkaline to phenolphthalein with a 10% NaOH soln. using a spot plate.
2. Add 10 ml. of 5% lead acetate soln. Mix well.
3. Filter.

4. Take a 105 ml. sample of the filtrate, or if appreciable quantities of NaOH have been required, take a sample which will correspond to 100 ml. of the original portion. Add 15% tartaric acid until the sample is acid to methyl orange, using a spot plate to test. Add 1 additional ml. of the tartaric acid solution. Dilute to 500 ml.
5. Using an all-glass distillation apparatus, distill over 50 ml., catching the distillate in a 100 ml. graduate containing 50 ml. of 2% NaOH. The discharge from the still should be through a tube two or three inches below the surface of the NaOH solution.

## II. Determination of Cyanide

### A. Reagents

$\text{AgNO}_3$  soln. equivalent to 0.1 mg  $\text{CN}^-$ /ml.

10% NaOH soln.

Indicator - p. dimethylamino benzalrhodanine 0.02% in acetone.

### B. Procedure

1. Bring sample to pH of 11 or 12 with 10% NaOH.
2. Add about 8-16 drops of indicator per 100 ml. of sample.
3. Titrate with  $\text{AgNO}_3$  soln. until yellow color turns to light salmon color.
4.  $\text{ppm cyanide as CN} = \text{AgNO}_3 \times 0.1 \times \frac{1000}{\text{ml. sample}}$

DETERMINATION OF SULFUR

1. To a neutral (or slightly alkaline) portion of sample add bromine until an excess is present. If alkaline the excess bromine is determined by acidifying a few drops to liberate the bromine.
2. Let stand 2-4 hours, or overnight.
3. Boil for several minutes, make barely acid with HCl, and reboil to remove the excess bromine.
4. Determine total sulfur by gravimetric method as given in Standard Methods (9th Edition, pp 83-4).

CHLORINE DEMANDReagents

Chlorine solution - approximately 0.5 mg/ml.

N/40 Sodium Thiosulfate

Potassium Iodide, C. P.

Acetic Acid, C. P.

Starch solution indicator

Procedure

1. Standardize chlorine solution according to Standard Methods (9th Edition) Page 148.
2. Add one, two, five, etc. ml. portions of the standard chlorine solution to suitable portions (or dilutions) of the sample, at two or three minute intervals. Chlorine dosage is staggered so that each individual titration can be made exactly 15 minutes after such dosage.
3. Immediately before titrating, acidify sample with acetic acid. This is necessary to obtain complete recovery of the residual chlorine.
4. Determine chlorine demand as in Standard Methods (9th Edition).

## APPENDIX B

Table 1 - Results of Analyses

Industry:  
Ford Motor Co., Dearborn, Mich.

| Source and Date        | Parts per million |               |              |              |          |              |          |      | Parts per million |                   |            |        |
|------------------------|-------------------|---------------|--------------|--------------|----------|--------------|----------|------|-------------------|-------------------|------------|--------|
|                        | Phenol            | Cyanide as CN | Ammonia as N | Total solids |          | Susp. solids |          | pH   | 5-day B.O.D.      | Total sulfur as S | Alkalinity |        |
|                        |                   |               |              | Total        | Volatile | Total        | Volatile |      |                   |                   | Phenol     | M.O.   |
| 1949                   |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Mill water             |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Oct. 30-31             | 0.03              | 0             | 0.24         | 162          | 76       | 12           | 4        | 8.4  | 1.2               | 7.0               | 0          | 98     |
| Oct. 31-Nov. 1         | .17               | 0             | .24          | 152          | 80       | 13           | 2        | 8.1  | 1.4               | 6.5               | 0          | 96     |
| Nov. 2-3               | .08               | 0             | .23          | 154          | 72       | 9            | 5        | 7.3  | 2.6               | 7.0               | 0          | 90     |
| Nov. 3-4               | .05               | 0             | .05          | 16           | 70       | 20           | 6        | 8.4  | 2.7               | 4.5               | 0          | 75     |
| Average                | .08               | 0             | .21          | 158          | 75       | 14           | 4        | 8.1  | 2.0               | 6.2               | 0          | 74     |
| Final cooler           |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Oct. 23-24             | 3.3               | 30            | 6.0          | 202          | 82       | 31           | 13       | 7.4  | 320               | 14                | 0          | 96     |
| Oct. 24-25             | 2.3               | 23            | 0            | 180          | 84       | 24           | 12       | 7.6  | 241*              | 4                 | 0          | 95     |
| Oct. 26-27             | -                 | 21            | 3.9          | 204          | 92       | 22           | 12       | 7.6  | 322               | 15                | 0          | 91     |
| Oct. 30-31             | 3.9               | 25            | 0            | 212          | 113      | 24           | 12       | 7.6  | 361               | 20                | 0          | 92     |
| Oct. 31-Nov. 1         | 4.7               | 25            | 6.4          | 202          | 120      | 36           | 16       | 7.6  | 496               | 31                | 0          | 114    |
| Nov. 2-3               | 4.3               | 22            | .5           | 180          | 75       | 12           | 7        | 7.6  | 424               | 16                | 0          | 93     |
| Average                | 3.6               | 26            | 3.1          | 204          | 91       | 25           | 12       | 7.6  | 325               | 13                | 0          | 95     |
| Ammonia still influent |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Oct. 23-24             | 675               | 64            | 9,950        | 14,700       | 14,600   | 51           | 43       | 10.0 | 2220              | 1650              | 13,000     | 19,900 |
| Oct. 24-25             | 537               | 125           | 10,900       | 13,300       | 13,200   | 44           | 42       | 10.1 | 2660*             | 1720              | 11,000     | 20,800 |
| Oct. 26-27             | 1070              | 104           | 9,960        | 13,500       | 13,400   | 43           | 40       | 10.1 | 2660              | 1540              | 15,400     | 21,600 |
| Oct. 30-31             | 1410              | 108           | 10,300       | 14,100       | 14,000   | 34           | 34       | 10.1 | 5020              | 2130              | 15,100     | 22,600 |
| Oct. 31-Nov. 1         | 1340              | 137           | 10,500       | 16,000       | 15,900   | 30           | 26       | 10.1 | 4500              | 1200              | 14,300     | 21,500 |
| Nov. 2-3               | 1560              | 147           | 10,600       | 16,700       | 16,600   | 32           | 25       | 10.2 | 4960              | 1440              | 15,800     | 25,200 |
| Average                | 1210              | 111           | 10,400       | 14,700       | 14,600   | 40           | 35       | 10.1 | 3070              | 1650              | 15,100     | 22,000 |
| Ammonia still effluent |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Oct. 23-24             | 649               | 2.9           | 1,260        | 17,400       | 11,500   | 616          | 202      | 8.2  | 1350              | 771               | 0          | 551    |
| Oct. 24-25             | 725               | .8            | 1,440        | 17,400       | 11,000   | 404          | 130      | 8.2  | 1690*             | 896               | 0          | 353    |
| Oct. 26-27             | 745               | 1.6           | 790          | 16,600       | 9,900    | 458          | 132      | 8.5  | 1320              | 906               | 0          | 482    |
| Oct. 30-31             | 925               | 1.6           | 1,310        | 17,400       | 9,900    | 532          | 285      | 8.5  | 2400              | 977               | 161        | 844    |
| Oct. 31-Nov. 1         | 896               | 3.3           | 662          | 17,000       | 9,460    | 1,350        | 470      | 8.6  | 2280              | 1000              | 131        | 1,300  |
| Nov. 2-3               | 1170              | .4            | 1,300        | 16,800       | 10,800   | 1,640        | 604      | 8.7  | 3200              | 587               | 211        | 1,810  |
| Average                | 852               | 1.6           | 1,130        | 15,900       | 10,400   | 680          | 304      | 8.5  | 2110              | 920               | 84         | 900    |
| Secondary decanter     |                   |               |              |              |          |              |          |      |                   |                   |            |        |
| Oct. 23-24             | 0.42              | 0             | 0.28         | 374          | 338      | 246          | 246      | 6.5  | 1730              | 8.1               | 0          | 2.9    |
| Oct. 24-25             | .61               | 0.19          | .22          | 90           | 70       | 224          | 224      | 6.6  | 470*              | 4.1               | 0          | 5.7    |
| Oct. 26-27             | -                 | .02           | .28          | 164          | 116      | 197          | 197      | 6.5  | Toxic             | 3.8               | 0          | 6.2    |
| Average                | .52               | .09           | .26          | 209          | 175      | 222          | 222      | 7.2  | -                 | 5.3               | 0          | 5.2    |

\* 6-day B.O.D. not used in average

TABLE 2 - CONSTITUENTS IN EFFLUENTS, PER 24 HOURS

Industry:  
Ford Motor Co., Dearborn, Mich.

| Source<br>and Date     | Pounds per day |        |                               |                   |                 |              |               |              |               |                         |
|------------------------|----------------|--------|-------------------------------|-------------------|-----------------|--------------|---------------|--------------|---------------|-------------------------|
|                        | Flow<br>M.G.D. | Phenol | Ammonia<br>as NH <sub>3</sub> | Cyanide<br>as HCN | 5-day<br>B.O.D. | Total solids |               | Susp. solids |               | Total<br>sulfur<br>as S |
|                        |                |        |                               |                   |                 | Total        | Vola-<br>tile | Total        | Vola-<br>tile |                         |
| 1949                   |                |        |                               |                   |                 |              |               |              |               |                         |
| Mill water             |                |        |                               |                   |                 |              |               |              |               |                         |
| Oct. 30-31             | 5.4            | 1.4    | 19                            | 0                 | 54              | 7,290        | 3,420         | 540          | 180           | 315                     |
| Oct. 31-Nov. 1         | 5.4            | 7.7    | 13                            | 0                 | 64              | 6,840        | 3,600         | 585          | 90            | 292                     |
| Nov. 2-3               | 5.4            | 3.6    | 13                            | 0                 | 117             | 6,930        | 3,240         | 405          | 225           | 315                     |
| Nov. 3-4               | 5.4            | 2.3    | 1.6                           | 0                 | 130             | 7,380        | 3,150         | 900          | 270           | 193                     |
| Average                | 5.4            | 3.8    | 12                            | 0                 | 91              | 7,110        | 3,350         | 606          | 131           | 279                     |
| Final cooler           |                |        |                               |                   |                 |              |               |              |               |                         |
| Oct. 23-24             | 5.4            | 150    | 328                           | 1400              | 14,400          | 9,090        | 3,690         | 1,390        | 450           | 855                     |
| Oct. 24-25             | 5.4            | 150    | 0                             | 1070              | -               | 7,200        | 2,430         | 1,060        | 540           | 180                     |
| Oct. 26-27             | 5.4            | -      | 213                           | 980               | 14,500          | 9,180        | 4,140         | 990          | 540           | 675                     |
| Oct. 30-31             | 5.4            | 156    | 0                             | 1170              | 25,200          | 9,540        | 5,310         | 1,080        | 540           | 900                     |
| Oct. 31-Nov. 1         | 5.4            | 211    | 459                           | 1170              | 22,300          | 9,090        | 5,400         | 1,570        | 720           | 1,390                   |
| Nov. 2-3               | 5.4            | 193    | 27                            | 1540              | 19,300          | 8,100        | 3,510         | 585          | 360           | 720                     |
| Average                | 5.4            | 172    | 171                           | 1220              | 19,100          | 8,700        | 4,080         | 1,120        | 525           | 790                     |
| Ammonia still influent |                |        |                               |                   |                 |              |               |              |               |                         |
| Oct. 23-24             | 0.065          | 475    | 6,540                         | 36                | 1,200           | 7,960        | 7,910         | 23           | 23            | 910                     |
| Oct. 24-25             | 0.062          | 510    | 6,830                         | 67                | -               | 6,870        | 6,820         | 23           | 22            | 888                     |
| Oct. 26-27             | 0.043          | 383    | 4,330                         | 39                | 953             | 4,840        | 4,800         | 15           | 14            | 663                     |
| Oct. 30-31             | 0.049          | 576    | 5,100                         | 46                | 2,050           | 5,760        | 5,710         | 14           | 14            | 657                     |
| Oct. 31-Nov. 1         | 0.063          | 703    | 6,690                         | 75                | 2,360           | 8,390        | 8,340         | 16           | 14            | 672                     |
| Nov. 2-3               | 0.071          | 923    | 7,610                         | 90                | 2,950           | 9,880        | 9,820         | 21           | 19            | 852                     |
| Average                | 0.059          | 595    | 6,180                         | 54                | 1,900           | 7,280        | 7,230         | 20           | 17            | 807                     |
| Ammonia still effluent |                |        |                               |                   |                 |              |               |              |               |                         |
| Oct. 23-24             | 0.078          | 422    | 994                           | 2.0               | 800             | 11,300       | 7,470         | 400          | 131           | 501                     |
| Oct. 24-25             | 0.074          | 447    | 1,080                         | 0.5               | -               | 8,880        | 6,780         | 249          | 80            | 552                     |
| Oct. 26-27             | 0.052          | 323    | 415                           | 0.7               | 570             | 6,760        | 4,290         | 198          | 57            | 392                     |
| Oct. 30-31             | 0.059          | 455    | 782                           | 0.8               | 1,180           | 7,080        | 4,870         | 409          | 142           | 480                     |
| Oct. 31-Nov. 1         | 0.076          | 567    | 509                           | 2.2               | 1,440           | 10,800       | 5,990         | 855          | 258           | 633                     |
| Nov. 2-3               | 0.085          | 828    | 1,120                         | 0.3               | 2,270           | 11,750       | 7,650         | 1,610        | 428           | 699                     |
| Average                | 0.071          | 507    | 820                           | 1.1               | 1,270           | 9,400        | 6,180         | 620          | 185           | 543                     |
| Secondary decanter     |                |        |                               |                   |                 |              |               |              |               |                         |
| Oct. 23-24             | 0.045          | 0.16   | 0.12                          | 0                 | 667             | 140          | 127           | 92           | 92            | 3.0                     |
| Oct. 24-25             | 0.045          | 0.23   | 0.10                          | 0.07              | -               | 34           | 26            | 84           | 84            | 1.5                     |
| Oct. 26-27             | 0.045          | -      | 0.12                          | 0.03              | -               | 62           | 44            | 74           | 74            | 1.4                     |
| Average                | 0.045          | 0.20   | 0.11                          | 0.05              | -               | 79           | 66            | 83           | 83            | 2.0                     |

# TABLE 3 - SUMMARY SHEET

Industry:

Ford Motor Company, Dearborn, Michigan

| Constituents      | Constituents in liquid discharge |            |               |            | Constituents chargeable to plant operation |            |               |            |
|-------------------|----------------------------------|------------|---------------|------------|--------------------------------------------|------------|---------------|------------|
|                   | Ammonia still                    |            | Final coolers |            | Ammonia still                              |            | Final coolers |            |
|                   | lb/day                           | % of total | lb/day        | % of total | lb/day                                     | % of total | lb/day        | % of total |
| Phenol            | 507                              | 74.7       | 172           | 25.3       | 507                                        | 75.1       | 163           | 24.9       |
| Cyanide as KCN    | 1.1                              | 0.1        | 1220          | 99.9       | 1.1                                        | 0.1        | 1220          | 99.9       |
| Ammonia as $NH_3$ | 820                              | 82.7       | 171           | 17.3       | 820                                        | 83.8       | 159           | 16.2       |
| 5-day B.O.D.      | 1270                             | 6.2        | 19,100        | 93.8       | 1270                                       | 6.3        | 19,000        | 93.7       |
| Total solids      |                                  |            |               |            |                                            |            |               |            |
| Total             | 9400                             | 51.9       | 8,700         | 48.1       | 9400                                       | 85.5       | 1,590         | 14.5       |
| Volatile          | 6180                             | 60.2       | 4,080         | 39.8       | 6180                                       | 89.4       | 730           | 10.6       |
| Suspended solids  |                                  |            |               |            |                                            |            |               |            |
| Total             | 620                              | 35.6       | 1,120         | 64.4       | 620                                        | 54.8       | 512           | 45.2       |
| Volatile          | 189                              | 26.5       | 525           | 73.5       | 189                                        | 36.1       | 334           | 63.9       |
| Total sulfur      | 543                              | 40.7       | 790           | 59.3       | 543                                        | 51.5       | 511           | 48.5       |